

In Support of HB 594:

EXHIBIT 1
DATE 2-18-2011
HB 594

"I ask you to vote favorably on HB594, requiring the use of post-consumer recycled material in highway projects. As Manager of Lake County's Solid Waste and Recycling programs and as President of Recycle Montana, I can tell you that the materials listed in the bill for possible incorporation into highway projects, are some of the most difficult materials to divert from burial in our landfills. MDOT previously proved in demonstration projects the viability of using glass and approved it for general usage. This bill does not ask for the materials to be subsidized, only that they be used when the cost is less than or equal to the cost of other materials used for the same purpose. Therefore, the taxpayers will not pay more for highways because of this bill. Meaning the bill should be revenue neutral to the State. However, by eliminating the cost of land filling these materials as waste products, there is an economic benefit. If these bulky materials are not reused, waste is all they are and there can be no resultant savings to local governments and their taxpayers from not burying them. Please vote yes on HB594."

Mark Nelson,
Ronan, Montana
406-429-3033

"We are pleased to support local uses for recycled products. Our business has nine full-time employees here in Belgrade serving the Greater Yellowstone Ecosystem. Anytime you can reduce transportation cost, you'll make it a more effective option. There is economic opportunity with this bill."

Dave Leverett, Vice-President
Four Corners Recycling
Belgrade, Montana
406.570.5561

In Support of HB 594:

"This would be a great way to support glass recycling, especially for our rural communities. Most of the state wants to recycle glass, but it needs support and a market. We need support from government and industry; HB 594 moves us in the right direction. Headwaters current serves Granite, Beaverhead, and Meagher Counties, as well as the towns of Lincoln, Choteau, Augusta, Harlowton, and Butte-Silver Bow. There is a demand to recycle glass, we just need a demand for the recycled glass."

Bill Crain, General Manager
Headwaters Recycling Cooperative
406.461.5601

"My name is Wendy Weaver and I am the co-founder of the Gallatin Zero Waste Coalition here in Gallatin County. I am writing today in support of HB 594. It is critical that we start maximizing and reusing our waste products in Montana instead of putting them under ground and finding useful second life for them. This in turn will help develop markets for recycled materials, including glass, concrete, etc. The Gallatin Zero Waste Coalition in Gallatin County has been working diligently to expand and promote waste reduction and recycling opportunities, and we believe this bill would help promote these opportunities."

Thank you for your consideration, Wendy Weaver, P.E.

Wendy Weaver. PE. LEED AP.
Sustainability Consultant
www.greenstone-consulting.com
Bozeman, Montana

A New Way to Control Cracking

SAMI, which stands for **Stress Absorbing Membrane Interlayer**, is a surface treatment that can be highly effective in stopping reflective cracking. SAMIs, which have been in use since the early 1970s in Arizona, are defined as a surface treatment that is placed prior to overlaying a road with hot mix asphalt. They are designed to resist the stress and strain of reflective cracks and delay the propagation of cracks through the new overlay.

A typical SAMI is constructed by spraying a thick layer of asphalt rubber on the roadway to be resurfaced. This asphalt rubber, which contains 20% to 30% crumb rubber, is applied at a rate of approximately 0.6 - 0.8 gal/sy (gallons per square yard). This is immediately covered with aggregate at a rate of 30 - 40 lbs/sy and rolled. This type of surface treatment is effective in stopping reflective cracking for several reasons. For one, the thick



This tanker is preparing to applying an ARMI in Florida

layer of asphalt rubber is very effective in sealing and waterproofing cracks. Secondly, the addition of the crumb rubber in the asphalt gives the SAMI elasticity that helps in absorbing the stress and strain that causes reflective cracking. Finally, the highly adhesive characteristic of asphalt rubber greatly improves the retention of the cover aggregate. This in turn reduces the aggregate loss during construction that can occur with typical surface treatments.



SAMI, which stands for **Stress Absorbing Membrane Interlayer**, is a surface treatment that is placed prior to overlaying a road with hot mix asphalt, and can be highly effective in stopping reflective cracking.

In the past few years, SAMIs have been used in Florida as well. Florida DOT's version of a SAMI is called an ARMI, or Asphalt Rubber Membrane Interlayer. This surface treatment has been quite effective in slowing or stopping reflective cracking in typical overlays, and has seen wide use throughout the state of Florida.

Another version of a SAMI is the SAM, which stands for Stress Absorbing Membrane. The SAM, which is constructed just like a SAMI, is a maintenance tool that is used as a final wearing course. SAMs are used like typical surface treatments and are placed on cracked roads to extend the service life of the road. By applying a SAM, the cracks in the old road are sealed, and a durable, flexible wearing course is placed on the road. SAMs have been used in Arizona since the late 1960s.

For more information on SAMs, SAMIs, and ARMIs, contact ARTS.?

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funded by six states and two corporations, and *Developing Specifications for Waste Glass and Waste-to-Energy Bottom Ash as Highway Fill Materials*, performed by the Florida Institute of Technology in 1995. Additional research that is applicable in whole or in part has been performed or sponsored by BFI of Ohio; the University of Missouri Rolla; the City of Oberlin, Ohio; and the Cold Regions Research and Engineering Laboratories.

The report consolidation section of this study compares duplicate tests performed by different laboratories to confirm or contradict the conclusions of the tests. The study also identifies and summarizes complementary tests to extend the conclusions of the tests.

The report also presents model specifications for glass aggregate. In part, the project is a four-year "retrospective" of the use of glass in Washington and other states. Special emphasis is given to "lessons learned," including site safety and health issues and quality assurance.

Tool Kit

The two sections described above are combined in one report of less than 100 pages. In the future, a "brochure" will be developed summarizing all of the results and giving model specifications in an accessible format not over eight pages.

The goal of this project is to have a package that can be used both for technical background and in presentations to any level of expertise. Photographic slides, videos, and a PC-based overhead presentation are also under production to fill out the presentation package. The CWC is available to present this material to any interested group.

Report Issue Date: December 1997

Fact Sheet Update: December 1997

For More Information

For a copy of the report, *A Tool Kit for the Use of Post-Consumer Glass as a Construction Aggregate (GL-97-5)*, use the CWC Publication Order Form. For more information call CWC at (206) 443-7746, email info@cw.org, or visit the CWC Internet Website at www.cw.org.

This technology brief was prepared by CWC, Managing Partner of the **Recycling Technology Assistance Partnership (ReTAP)**. ReTAP is an affiliate of the national Manufacturing Extension Partnership (MEP), a program of the U.S. Commerce Department's National Institute of Standards and Technology. ReTAP is also funded by the U.S. Environmental Protection Agency and the American Plastics Council.

CWC is a division of the Pacific NorthWest Economic Region, 2200 Alaskan Way, Suite 460, Seattle, Washington, 98121.

Technology Brief

A Tool Kit for Using Recycled Glass as a Construction Aggregate

The use of recycled glass as a construction aggregate has been technically well-established, with over 50,000 tons used in construction projects in the state of Washington alone. In addition, Department of Transportation specifications in at least six states have been amended, allowing the use of recycled glass in road projects.

However, a continuing barrier to increased construction use has been the lack of a single document consolidating the primary technical research and practical field experience to give engineers, in a single document, all of the information they need to specify recycled glass aggregate with confidence.

The CWC, along with Soil and Environmental Engineers (S & EE) of Redmond, Washington, and Re-Sourcing Associates of Seattle, has created this recycled glass aggregate "tool kit." The tool kit includes case studies, lessons learned, and a summary of the findings of several important technical studies.

Case Studies

The report uses a standard format to capture the pertinent experience from existing projects incorporating recycled glass aggregate. Among the data captured for six projects in Washington and three outside of Washington is:

- type of aggregate application
- location
- gradation
- material specifications
- volume



Key Words

Materials: Recycled Glass.

Technologies: Performance of Glass Construction Aggregate.

Applications: All unbound aggregate applications.

Market Goals: Outlet for low-value and mixed-color recycled glass.

Abstract: A Tool Kit consolidating case studies and research reports on glass aggregate.

- economics
- special handling procedures
- lessons learned
- contact people

The case studies develop the information shown above for a wide variety of aggregate applications (e.g. road base, lightweight fill, drainage aggregate, retaining wall backfill, utility trench backfill, etc.). A wide variety of uses are shown in order to provide real-world experience in actual applications, and to increase the confidence of specifying engineers that they do not need to "re-invent the wheel" in order to specify recycled glass aggregate in their projects.

Report Consolidation

Two major studies and several smaller studies have analyzed the technical performance of glass as a construction aggregate. The two major studies are *The Glass Feedstock Study*, performed by Dames & Moore consulting engineers of Seattle in 1993, and

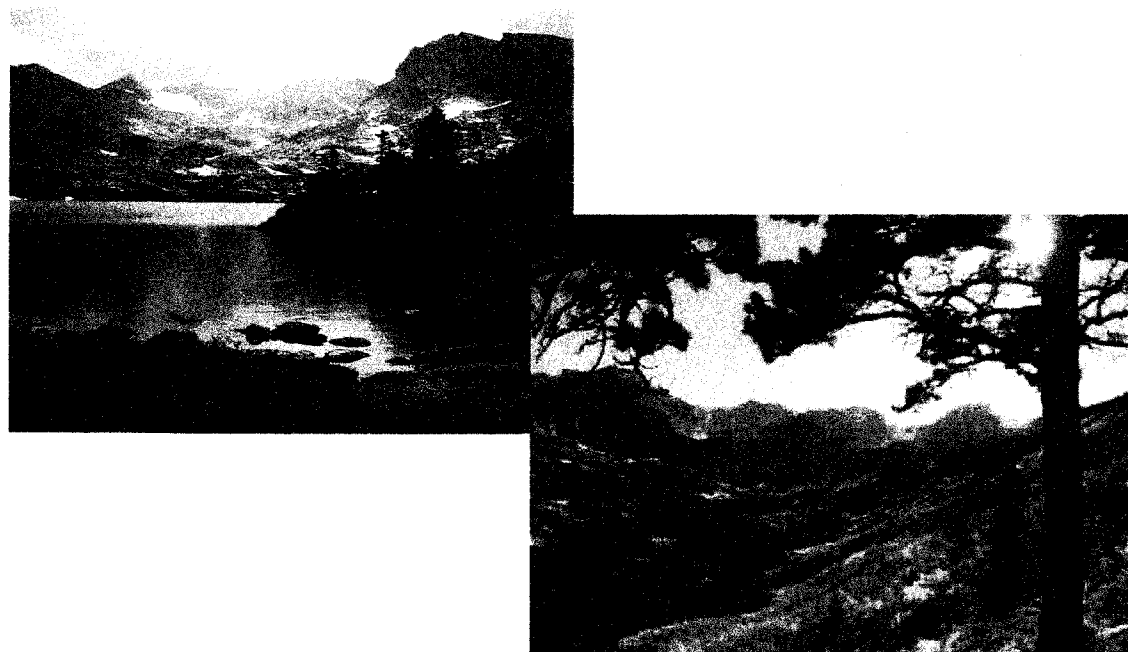
In Support of HB 594:

I support HB594, for numerous reasons. I own Helena Recycling, a curbside recycling business location in Helena, Mt. Currently we do not accept glass because we do not have an outlet for it. Our customers have asked us time and time again when are we going to take glass. I believe with HB594, it will make it possible for us to not only take glass, but to look at other items such as old tires. These are both items that should be kept out of the waste stream and put back into use. This will also help create economic opportunities, including jobs, in the state of Montana. Montana is a great state and why wouldn't we want use recycled materials!

John Hilton, Owner
Helena Recycling, LLC
1065 Strawberry Dr.
Helena, MT 59601
406-459-8521

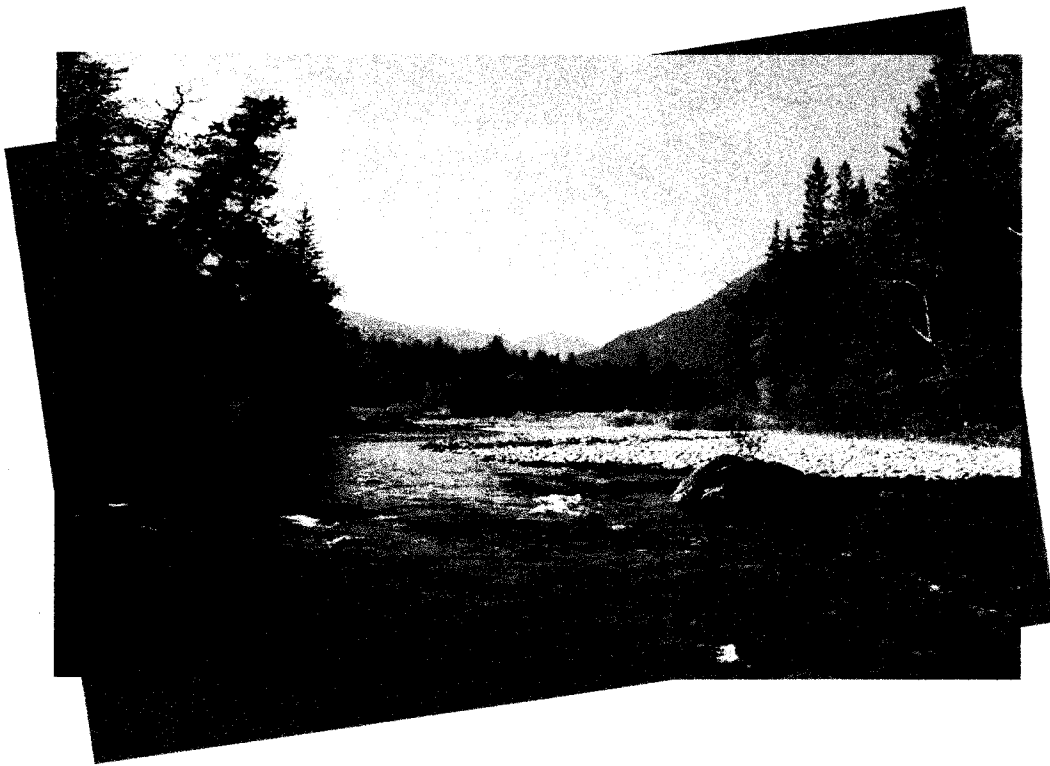
The Economic and Ecological Impacts of Recycling in Montana

Throughout the United States, recycling has resulted in economic growth, income growth, net job increases, long-term investment, energy savings, waste reduction, lower production costs for many industries, and an extension of the life of landfills. According to the California Environmental Protection Agency, waste *diversion* of any type, including recycling, tends to create twice the economic activity per ton of conventional waste *disposal*¹. Recycling also reduces pollution and conserves natural resources, which leads to cleaner air and water, and it increases open space and reduces greenhouse gases. This paper will look at the impact of recycling on Montana's economy.



¹ Found in the pamphlet, *Is Recycling good for California's Economy?*.

The Economic *and* Ecological Impacts *of* Recycling in Montana



July 2004



Air, Energy, and Pollution Prevention Bureau
Business & Community Assistance Program
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Helena, MT 59620-0901

The Impact of Recycling on the U.S. and Other States

Before discussing the impact of recycling on Montana's economy, it is informative to look at the impact of recycling on other states and on the U.S. as a whole. The National Recycling Coalition recently conducted a comprehensive national survey of the impact of recycling on the U.S. economy. This survey was titled *U.S. Recycling Economic Information Study* (REI Study) and was conducted by R.W. Beck Inc. for the National Recycling Coalition Inc. (July 2001). According to the study, there are three main types of businesses in the U.S. recycling sector. These are collection, processing, and manufacturing/sales. There is also a fourth type of business sometimes mentioned which is the reuse and remanufacturing of goods. According to the *U.S. Recycling Economic Information Study-Executive Summary*, "The Recycling sector includes long-established sectors like paper and steel making, as well as new entrepreneurial ventures such as composting and plastic and rubber product manufacturers" (page ES-4). Examples of specific establishments in the U.S. recycling sector include government and private curbside collection programs, compost and miscellaneous organics products producers, materials recovery facilities, and recyclable material wholesalers.

In the U.S., using 1997 Census data, the Recycling and Reuse Industry as defined by Census NAICS codes employed just over 1 million people at 56,000 establishments generating an annual payroll of approximately \$37 billion and grossing over \$236 billion annually in revenues including direct and indirect economic impacts (*U.S. Recycling Economic Information Study*). The average annual wage in that industry was about \$32,700 nationwide in 1997, which was about \$3,000 per year more than the national average wage at that time. The Recycling and Reuse Industry in the U.S. produced over \$200 billion in total wages and sales, which was comparable to both the Machinery Manufacturing and Mining industries.

The average annual wage in the Recycling and Reuse Industry was about \$32,700 nationwide in 1997, which was about \$3,000 per year more than the national average wage at that time.

Two studies done in California found that reuse and recycling activities actually create more total sales, income and jobs in California than solid waste disposal activities. These two studies are a University of California, Berkeley study entitled *The Economic Impact of Waste Disposal and Diversion in California (UCB study)* and a R.W. Beck Inc. and the National Recycling Coalition study entitled *The California Recycling Economic Information (REI) Study*. The UCB study estimated total economic output from recycling in California in 1999 of about \$10 billion in revenues, \$4 billion in income created, \$5 billion in value-added impact, and 85,000 jobs. About \$100 million in annual sales tax revenue was created from recycling in California.

Ohio is a U.S. leader in recycling, due in part to the large amount of material-intensive industry found there. In Ohio, the total economic impact of the recycling industry (both direct and indirect impacts) in 2001 was approximately 169,000 jobs, \$6 billion in annual wages and \$30 billion in annual sales. The recycling industry supported directly or indirectly 4.3 percent of the jobs and 3.7 percent of gross state product in Ohio in 2001. The average annual wage paid by

The Impact of Recycling on the U.S. and Other States - *continued from page 3*



Ohio's recycling industry was \$36,000 or \$8,000 more than the state average in 2001. On an annual basis, Ohio's recycling industry contributes about \$650 million in tax revenue to state and local government. Ohio boasts a very large aluminum recycling program and in-state manufacturers use the bulk of that material. It is estimated that Ohio saves about 1.6 billion tons of greenhouse gases annually from paper recycling alone. The Ohio recycling industry annually processes 30 million tons of materials including 16 million tons imported into Ohio for processing and manufacturing into new products. (*Recycling Means Business*, pamphlet issued by the Ohio Department of Natural Resources).

The Economic Impacts of Recycling in Montana

Like other states, Montana's recycling sector is diverse and significant. The types of companies in Montana that are involved in recycling are:

- City/County transfer stations
- Recycling haulers and collectors
- Retailers of recycled materials and products made of recycled materials
- Manufacturers of recycled materials
- Recycling processors
- Producers and sellers of organic compost

There are a significant number of recycling collection centers in Montana, and often more than one in the larger towns. Headwaters Recycling Co-op operates the largest number of collection centers in the state. The Headwaters Recycling Co-op is an interlocking government agreement between 13 counties. Their centers are located mostly in central, southern and southwestern Montana. Pacific Steel and Recycling also operates several large recycling facilities in the state. Materials recycled at the various collection centers throughout Montana include newspaper, office paper, magazines, aluminum cans, steel cans, metals, glass, plastic, motor oil, clothing and cardboard. Not every center recycles all of these materials (Recycle Montana website, <http://recyclemontana.org/where.htm>)



Establishments that currently sell recycled and re-used goods in Montana are diverse. Montana companies sell clothing made from recovered cotton, used car parts restored from previous vehicles, insulation made out of post-consumer products, re-tread truck tires, and reused building materials from flooring to roofing. Three Montana companies sell Plum Creek Lumber Company's medium density fiberboard made from the sawdust and shavings produced in lumber and plywood operations. Also, the Montana Chamber of Commerce and Montana State University Extension Service sponsor the Montana Material Exchange, which helps businesses find buyers for surplus materials and helps individuals or businesses locate these materials.

The Economic Impacts of Recycling in Montana - *continued from page 4*



Several companies in Montana sell compost, which is made from yard and wood wastes. Other companies in Montana offer flooring tiles made from 100 percent recycled material, carpet and padding made from recycled materials, salvaged wood flooring, recycled paper at food stores, and cardboard with recycled content. Numerous companies sell plastic lumber and plastic/wood composite lumber. Other Montana companies sell toner cartridges that can be remanufactured after use, recycled office supplies, duffel bags, CD cases, binders, photo albums, toothbrushes, and trash bags. (2003-2004 Montana Guide for Buying Recycled Products, Montana Department of Environmental Quality).

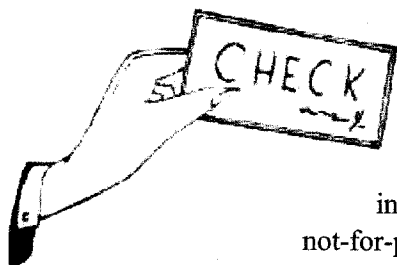
The state government of Montana purchases and uses recycled products. All of state government letterhead paper contains 25% post-consumer content. About 89% of Montana state government agencies use copy paper with some recycled content. About 1/3 of the envelopes used by state agencies contain 30% post-consumer content. All coarse paper products sold through the Department of Administration Central Stores contain from 10 to 40 percent post-consumer content. The Montana Department of Transportation purchased 1.5 million pounds of reflective beads for pavement striping in Fiscal Year 1999 which were manufactured from plate glass cuttings. Remanufactured toner cartridges and trash bags with 50% post-consumer content material were also sold by the Montana Department of Administration to state agencies.

The state program "3R's in State Government" (which involves state agencies) recycled 2,080 tons of paper from 1996-2003. More than half of that, over 1,300 tons, was office paper. Other types of paper recycled by state government include newspaper, cardboard and computer paper. In 2003 alone, 3R's recycled about 340 tons of paper. (2003 Montana Department of Administration Recycling Report).

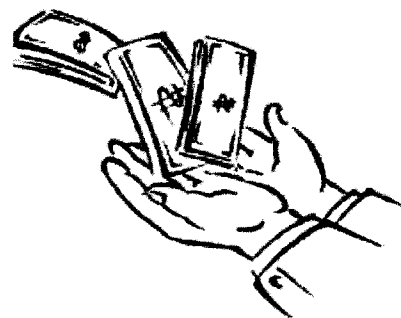
Overall Economic Numbers

The Recycling Industry in Montana is significant. In 2003, the industry paid over nine million dollars in wages and benefits to approximately 300 full-time and 40 part-time employees.

Total gross revenues for the industry in 2003 were almost 90 million dollars and the average wage per full-time job (including benefits) was about \$29,000 a year, which is several thousand dollars greater than the average wage in Montana (about \$25,800 in 2002 according to the U.S. Bureau of Economic Analysis). These totals include recycling activity at all levels including processing, collection, remanufacturing, and sales. The totals include the private sector, public sector and not-for-profit entities.



The largest component of recycling in Montana is the for-profit private sector, which is the traditional backbone



Overall Economic Numbers - continued from page 5

for recycling in Montana. Manufacturing was the largest recycling activity in Montana and the processing of recycled materials was the second largest activity. The total economic numbers below were largely concentrated within several individual businesses. The approximate numbers for 2003 are as follows:²

Full Time Jobs:	300
Part Time Jobs:	40
Wages (+ benefits)*:	\$ 9,330,000
Revenues:	\$89,120,000

* Assuming benefits to be \$.15 per \$1.00 wage for survey respondents who did not give benefit amounts.

The average wage (including benefits) in Montana's recycling industry was calculated to be about \$29,000 ($9,332,580/321.5 = \$29,028$). Total avoided landfill costs in 2002 as a result of recycling were estimated to be \$4,615,776—128,216 tons recycled which avoided landfill at a fee of \$36.00 per ton. (*Brian Spangler, Montana Department of Environmental Quality*). There are also indirect positive economic effects from recycling and tax revenues collected from the recycling industry in Montana. Estimating these numbers is beyond the scope of this paper.

Environmental Impacts of Recycling in Montana

The amount of total waste generated in Montana in 2002 was 1,194,243 tons. The amount of waste landfilled was 1,004,635 tons or about 84% of total waste and the amount incinerated was 13,037 tons or about 1% of total waste. The total amount of waste that was recycled was 128,216 tons or 11% of the total generated. Four percent or 48,355 tons were composted. So, about 15% of Montana's total waste was either recycled or composted. The 128,216 tons recycled was reported from 12 different companies/public facilities in Montana with Pacific Steel being the largest recycler overall. Eight companies comprised the 48,355 tons of composted material (Montana Department of Environmental Quality, Air, Energy, and Pollution Prevention Bureau).

In 2002, numbers were estimated for total tonnage of recycled materials in Montana. The tonnage numbers were collected from landfills and transfer reports submitted to the Solid Waste Department at DEQ. These numbers were obtained from landfills, transfer facilities and

² These results were produced by a survey conducted by the Air, Energy and Pollution Prevention Bureau of the Montana Department of Environmental Quality in the Spring of 2004. Matt Elsaesser was the principle investigator of the survey. The results do not include the small number of contacts that did not respond to the survey, nor the activity of sole proprietors who are not listed or advertised as a public business or recycling operation. Emerging companies and recycling components of large institutions are for the most part not included in this survey. Recycling activity for this project included the collection, transport, processing, remanufacturing and sale of post consumer products. It includes composting as recycling activity, but does not include wrecking yards. The list of participants to meet these criteria was constructed using the State Database, Recycle Montana Recycling Guide, a D.E.Q. mailing list, telephone directories and staff knowledge. The survey was conducted primarily by phone, with letters sent for some respondents by their request.

Environmental Impacts of Recycling in Montana - continued from page 6

recyclers through an annual survey. Montana DEQ went through the reports to gather and summarize the information. Individual names and towns are not reported due to confidentiality concerns.

In 2002, there was a total of 128,216 tons of total recycled material in Montana. The estimated numbers for the tonnage recycled of specific major materials are:



Bozeman Landfill

Cardboard -	77,642
Paper-	27,167
Aluminum-	21,977
Steel-	1,428
Plastic	<u>172</u>
Total	128,216

The recycling of each of these materials results in not only economic benefits but also in ecological benefits for Montana. Using the National Recycling Coalition (NRC) Calculator, the Net Greenhouse Gas Emissions from Recycling in Montana compared to disposal is 178,722 Metric Tons Carbon Equivalent (MTCE/year) lower, which is equal to taking approximately 136,523 cars off the road per year. The net energy from recycling compared to disposal is estimated at 7,082,247 million BTU, which is equivalent to what is used by just over 70,000 households per year. An estimated reduction of 159,656 tons of air emissions results from Montana recycling, including a 149,599 ton reduction in carbon dioxide. About 592 tons of waterborne wastes are avoided as well. About 2,870 total tons of natural resources are saved annually.

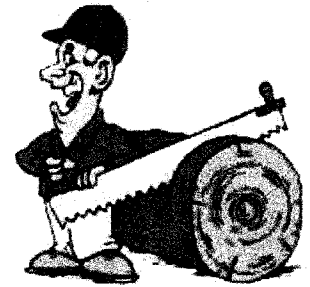
Un-quantified Benefits from Recycling

As demonstrated above, the economical, environmental and social benefits of reducing pollution from recycling are diverse and significant for Montana. Although we cannot quantify some of these benefits monetarily in this study, we can certainly list them. For example, reducing air pollution from recycling leads to the following benefits in Montana:

- Health benefits (reduced human morbidity and mortality)
- Recreation benefits (especially to Class 1 areas like Glacier National Park)
- Increased visibility
- Lower levels of materials damage such as office buildings
- Agricultural benefits
- Ecosystem benefits (local and worldwide) including lower levels of greenhouse gas emitted and healthier forests

Un-quantified Benefits from Recycling - *continued from page 7*

There are also water quality benefits and the benefits of consuming less virgin resources which all translate eventually into monetary benefits. For example, if less trees need to be logged as a result of recycling, then this helps forest health and helps decrease soil erosion as well as leaving more trees for future generations and other species.



Conclusion

Recycling in Montana is more than just a fad; it is a real industry. Even without any form of mandatory recycling or other specific in-state mandate to foster recycling, this industry creates and sustains many full-time, reasonably well-paying jobs. With our continued growth in consumption and need for recycling, these numbers are likely to grow over time. The networks that enable recycling in Montana are mostly private. Recycling activity in Montana is a model point for the interplay between private sector activity and social concern—between economic incentive and environmental responsibility. Recycling in Montana has a vibrant economic base that reaches throughout the majority of the state. It has a tremendous opportunity for future growth.



Acknowledgements

The data was gathered and compiled by an intern, Matt Elsaesser, who recently graduated from Carroll College and wrote his thesis on recycling. The report was written by Jeff Blend, Economist, PhD, DEQ.



Chipped Tires In Lightweight Embankments

When people talk about using recycled tires in highway construction, rubber modified asphalt is quite often the only option that is discussed. Waste tires however can be used in a variety of ways in building roads. One of the most innovative is using chipped tires as lightweight fill material for embankments.

yard of fill. One project completed in Maine used 200,000 tires in a 400 foot long embankment.

The chipped tires that are used in lightweight fills are much larger than the crumb rubber used for rubber modified asphalt. Typically, chipped tires in the lower portion of the fill are 75% passing

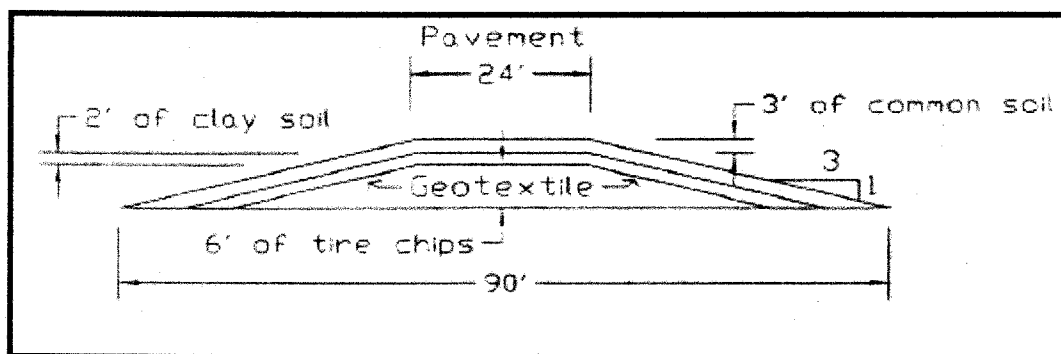
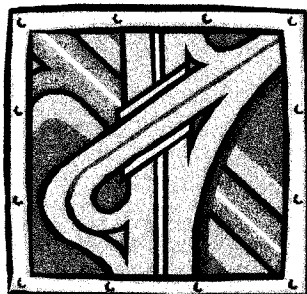


Figure 1: Typical Chipped Tire Lightweight Embankment

Using chipped tires as a fill material has several advantages. One of the most obvious is that chipped tires are extremely lightweight when compared to standard fill materials. Compacted, chipped tires have a dry unit weight ranging from 38 pcf to 43 pcf (per cubic foot). This is significantly less than most compacted soils that have a dry unit weight of approximately 125 pcf. With this low unit weight, chipped tire fills can be used in embankments over soft or weak foundation materials to prevent settling and increase the stability of the embankment.

Another advantage in using chipped tires as fill material is that a large volume of tires can be recycled. For example, a tire fill that has a unit weight of 43 pcf can use approximately 73 tires per cubic



the 8 inch sieve and around 25% passing the 1½ inch sieve. In the upper part of the fill, 100% of the chips are required to pass the 2 inch sieve with 99% retained on the #4 sieve.

A typical chipped tire fill is shown in Figure 1. In order to contain the chipped tires and to prevent contamination from underlying or overlying soils, the compacted chips are enclosed in a geotextile membrane. To protect the chips from air and water, the fill is then covered with a minimum of 2 feet of clay soil and 3 feet of common soil. Although the tires only make up the central core of the fill, the overall weight of the embankment can be significantly reduced while also recycling thousand of tires.

The advantage of the low unit weight of chipped tires as well as the recycling opportunities make chipped tires a very feasible alternative in constructing lightweight embankments. ?

INDUSTRIAL BY-PRODUCT USE IN HIGHWAYS and ROADWAYS

It is estimated that roadway and highway construction in the United States is currently consuming between 500 and 800 million metric tons of virgin crushed rock, gravel and sand each year as aggregate. The existing annual quantities of industrial by-product source materials, some 600 million metric tons, represents a way to significantly reduce the amount of virgin materials required for transportation infrastructure projects, natural resources, address energy and climate change issues and reduce the need for landfill space.

EVALUATION and ASSESSMENT of OPPORTUNITIES

The materials matrix represented in Figure 1.0 prepared by the Industrial Resources Council, shows six major groups of by-product materials in the column headers, with the rows as potential applications.

The industrial by-products are divided into six major groups:

- Coal Combustion Products
- Iron and Steel Slag Products
- Foundry Slags and Sands
- Tire Derived Rubber Materials
- Recycled Concrete Materials
- Paper Production Materials

Check marks indicate that a particular material-application combination has been used successfully, and that adequate data are available to prepare a description of the physical and chemical properties of the material and to describe the design requirements and performance records for one or more specific applications.

Omission of a particular material-application match in this matrix is not to be construed as a prohibition against its use; rather, omission indicates that either the material-application combination was inappropriate or that insufficient information was available to provide useful/accurate guidance.



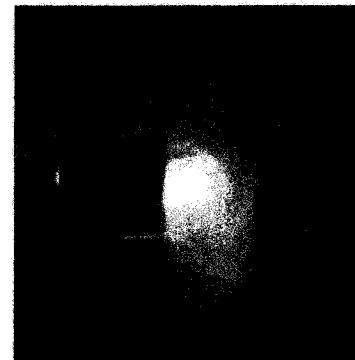
Recycled Course Concrete Aggregate



Recycled Tires



Recycled Asphalt Milling Operation



Electric Arc Furnace Slag



GREEN HIGHWAYS PARTNERSHIP OFFICE

RECYCLE & REUSE TEAM

GOALS:

Promote environmentally sound and technically acceptable use of industrial materials in transportation infrastructure projects.

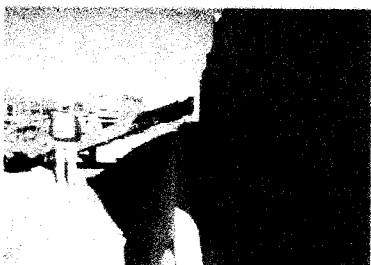
Promote practices that conserve non-renewable resources, reduce impacts to landfills, reduce greenhouse gas emissions, and save energy.



Grading Foundry Sand for Road Subbase

Approximately 500,000 to 700,000 tons of foundry sand are used annually in engineering applications, most often in geotechnical applications.

(FHWA-IF-04-004)

Placing tire shreds behind road abutment
(Rubber Manufacturers Association)Crushed glass between jersey barrier and sound wall
(Schnabel Engineering)

INDUSTRIAL MATERIALS RECYCLING

Nearly every industrial process, from manufacturing to generating energy, produces many different types of usable industrial by-products. The table below includes examples of some of the material reuses in transportation.

INDUSTRIAL MATERIALS

CAN BE RECYCLED IN:

Coal Combustion Materials

- Fly Ash
- Boiler Slag
- Flue Gas Desulfurization Material
- Bottom Ash

Portland cement and concrete, flowable and structural fill, wallboard panel products and agricultural applications

Construction and Demolition Debris

- Concrete and RAP
- Gypsum and Drywall
- Brick and Block

Added to asphalt and concrete paving, concrete mixes, road base and sub-base

Foundry Sand

- Spent sand used in metal casting

Road embankments, manufactured soils, flowable and structural fills, road base and sub-base

Steel Production Materials

- Electric Arc and Blast Furnace Slag

Added to bioretention or infiltration beds to remove phosphorous, added to concrete as aggregate for road base and sub-base

Consumer By-products

- Crushed Glass
- Shredded Tires

Base, sub-base, fill and filter media, Road material mixes, Energy Generation

BENEFITS of RECYCLED and REUSED MATERIALS

Conservation of Non-renewable Resources - Lime, gypsum, and aggregate are examples of mined materials which can be substituted with various recycled materials. New mines destroy green fields and impact wildlife habitat.

Reduced Energy Consumption and Greenhouse Gas Emissions- Virgin materials require energy intensive mining operations and often very energy intensive manufacturing and refinement which recycled or reused materials can help to reduce. For example, coal fly ash can be used to replace 20 percent or greater amounts of Portland cement in concrete. In addition, using local materials reduces transportation emissions, while in-place recycling can help conserve resources, costs and reduce the carbon footprint.

Reduced Land filling- Reusing industrial by-products reduces the need for additional landfill space. New landfill space can be costly and often involves lengthy permitting processes.

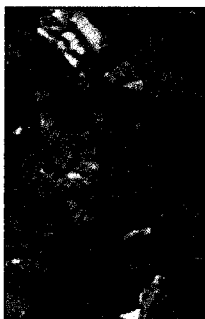
Reducing Repeated Cost- Recycled materials often have less transportation and refinement costs. Also, the costs associated with disposing of material is eliminated. Recycled materials often cost less than conventional/virgin materials.

Better Material Properties- Many reused and recycled materials perform better than the material they replace or bring additional performance benefits. Slag cement has a higher reflectivity than other cementitious materials. Lighter color concrete absorbs less heat, helping minimize the heat island effect. In another example, crushed glass has a higher frictional characteristic.

Production of Crumb Rubber Modifier

Crumb Rubber Modifier (CRM) is the term used to describe ground waste tire rubber used in Hot Mix Asphalt and other paving applications. Crumb Rubber Modifier (CRM) material can be produced several different ways:

- Ambient Grinding
- Cryogenic Grinding
- Wet Grinding



1/2" pieces (#12 mesh)

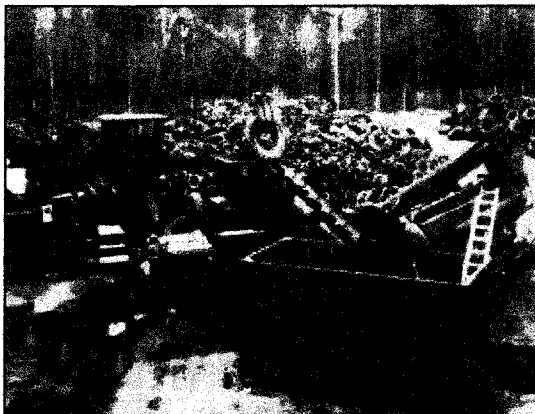
Each of these methods requires that the whole tires first be fed through a shredder and then a chopper to reduce the chip size to approximately 3" to 1/2" pieces. Once this is accomplished, any one of the grinding processes can be utilized.

Ambient Grinding

Ambient Grinding requires that the CRM be sized at ambient room temperature. This is generally accomplished with a series of grinders and screens to size the material, magnets to remove any residual steel, and some form of fiber removal system. Ambient Grinding can produce material ranging in size from 1/4" mesh to #40 mesh. Ambient Grinding produces a material with a very rough surface texture. This rough surface texture reacts more thoroughly with asphalt cements, thus resulting in a more desirable Asphalt Rubber binder.

Cryogenic Grinding

Cryogenic Grinding is similar to ambient grinding with the exception that the waste rubber is first cooled and made brittle with liquid nitrogen. This cooled rubber can then be sized quite easily with a process similar to the Ambient Grinding process.



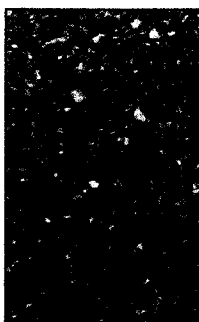
Shred-Tech ST-500H Transportable Shredding System

Cryogenic Grinding can produce material ranging in size from 1/4" mesh to #100 mesh. Cryogenic Grinding produces a material with a very smooth surface texture which reacts less thoroughly with asphalt cements than ambiently ground CRM.

Wet Grinding

Wet Grinding utilizes an already ground, coarse CRM material in a wet slurry. This slurry is then ground between grinding stone. This process is useful due to the fact that it can produce a finer material (1/4" mesh to #100 mesh) than normal ambient grinding, but it still retains the rough surface texture of a normal ambient ground material. This finer material with a rough surface texture results in a very thorough reaction with

asphalt cement, but must be dried before it can be used. ?



2mm-0.5 mm (#10-35 mesh)



0.5 mm (#35 mesh)

Tire Chip photos used with permission of RUMAL.